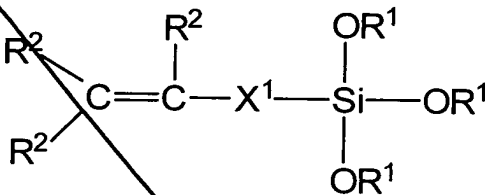


W claim:

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- 10
1. A method of treating a metal surface, comprising the steps of:
- (a) providing a metal surface, said metal surface chosen from the group consisting of:
- a metal surface having a zinc-containing coating;
 - zinc; and
 - zinc alloy;
- and
- (b) applying a silane solution to said metal surface, said silane solution having at least one vinyl silane and at least one bis-silyl aminosilane, wherein said at least one vinyl silane and said at least one bis-silyl aminosilane have been at least partially hydrolyzed.

2. The method of claim 1, wherein said vinyl silane has a trisubstituted silyl group, and wherein the substituents are individually chosen from the group consisting of hydroxy, alkoxy, aryloxy and acyloxy.

3. The method of claim 2, wherein said vinyl silane comprises:



wherein:

-each R^1 is individually chosen from the group consisting of: hydrogen, $\text{C}_1 - \text{C}_{24}$ alkyl and $\text{C}_2 - \text{C}_{24}$ acyl;

5 - X^1 is chosen from the group consisting of: a C-Si bond, substituted aliphatic groups, unsubstituted aliphatic groups, substituted aromatic groups, and unsubstituted aromatic groups; and

Sub D1
cont.

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each R^2 is individually chosen from the group consisting of: hydrogen, $C_1 - C_6$ alkyl, $C_1 - C_6$ alkyl substituted with at least one amino group, $C_1 - C_6$ alkenyl, $C_1 - C_6$ alkenyl substituted with at least one amino group, arylene, and alkylarylene.

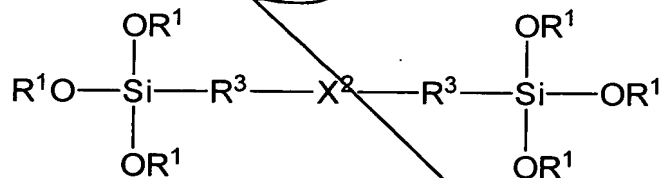
4. The method of claim 3, wherein each R^1 is individually chosen from the group consisting of: hydrogen, ethyl, methyl, propyl, iso-propyl, butyl, iso-butyl, sec-butyl, ter-butyl and acetyl.

5. The method of claim 3, wherein X^1 is chosen from the group consisting of: a C-Si bond, $C_1 - C_6$ alkylene, $C_1 - C_6$ alkenylene, $C_1 - C_6$ alkylene substituted with at least one amino group, $C_1 - C_6$ alkenylene substituted with at least one amino group, arylene, and alkylarylene.

6. The method of claim 3, wherein each R^2 is individually chosen from the group consisting of: hydrogen, ethyl, methyl, propyl, iso-propyl, butyl, iso-butyl, sec-butyl, ter-butyl and acetyl.

7. The method of claim 1, wherein said bis-silyl aminosilane comprises an aminosilane having two trisubstituted silyl groups, wherein the substituents are individually chosen from the group consisting of hydroxy, alkoxy, aryloxy and acyloxy.

8. The method of claim 7, wherein said bis-silyl aminosilane comprises:

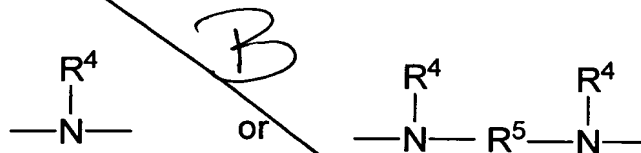


wherein:

-each R^1 is individually chosen from the group consisting of: hydrogen, $C_1 - C_{24}$ alkyl and $C_2 - C_{24}$ acyl;

- 5 ~~each R³ is individually chosen from the group consisting of: substituted aliphatic groups, unsubstituted aliphatic groups, substituted aromatic groups, and unsubstituted aromatic groups; and~~

~~-X² is either:~~



- 10 ~~-wherein each R⁴ is individually chosen from the group consisting of: hydrogen, substituted and unsubstituted aliphatic groups, and substituted and unsubstituted aromatic groups; and~~

~~-R⁵ is chosen from the group consisting of: substituted and unsubstituted aliphatic groups, and substituted and unsubstituted aromatic groups.~~

9. ~~The method of claim 8, wherein each R¹ is individually chosen from the group consisting of: hydrogen, ethyl, methyl, propyl, iso-propyl, butyl, iso-butyl, sec-butyl, ter-butyl and acetyl.~~

10. ~~The method of claim 8, wherein each R³ is individually chosen from the group consisting of: C₁ - C₁₀ alkylene, C₁ - C₁₀ alkenylene, arylene, and alkylarylene.~~

11. ~~The method of claim 8, wherein each R⁴ is individually chosen from the group consisting of: hydrogen, C₁ - C₆ alkyl and C₁ - C₆ alkenyl.~~

12. ~~The method of claim 8, wherein R⁵ is chosen from the group consisting of: C₁ - C₁₀ alkylene, C₁ - C₁₀ alkenylene, arylene, and alkylarylene.~~

13. ~~The method of claim 1, wherein said bis-silyl aminosilane is chosen from the group consisting of: bis-(trimethoxysilylpropyl)amine, bis-(triethoxysilylpropyl)amine, and bis-(triethoxysilylpropyl)ethylene diamine.~~

Sub D1
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14. The method of claim 1, wherein said vinyl silane is chosen from the group consisting of: vinyltrimethoxysilane, vinyltriethoxysilane, vinyltripropoxysilane, vinyltriisopropoxysilane, vinyltributoxysilane, vinyltriisobutoxysilane, vinylacetoxysilane, vinyltriisobutoxysilane, vinylbutyltrimethoxysilane, vinylmethyltrimethoxysilane, vinylethyltrimethoxysilane, vinylpropyltrimethoxysilane, vinylbutyltriethoxysilane, and vinylpropyltriethoxysilane.

15. The method of claim 1, wherein the ratio (by volume) of the total concentration of vinyl silanes to the total concentration of bis-silyl aminosilanes in said silane solution is at least about 1.

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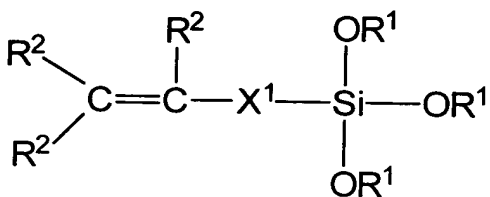
16. The method of claim 1, further comprising the steps of drying said metal surface after said silane solution has been applied thereto, and thereafter coating said metal surface with a polymer selected from the group consisting of: paints, adhesives and rubbers.

17. The method of claim 1, wherein said metal surface comprises hot-dipped galvanized steel.

18. An aqueous solution comprising at least one vinyl silane and at least one bis-silyl aminosilane, wherein said at least one vinyl silane and said at least one bis-silyl aminosilane are at least partially hydrolyzed.

19. The solution of claim 18, wherein said vinyl silane has a trisubstituted silyl group, wherein the substituents are individually chosen from the group consisting of hydroxy, alkoxy, aryloxy and acyloxy.

20. The solution of claim 19, wherein said vinyl silane comprises:



wherein:

-each R¹ is individually chosen from the group consisting of: hydrogen, C₁ - C₂₄ alkyl and C₂ - C₂₄ acyl;

5 -X¹ is chosen from the group consisting of: a C-Si bond, substituted aliphatic groups, unsubstituted aliphatic groups, substituted aromatic groups, and unsubstituted aromatic groups; and

10 -each R² is individually chosen from the group consisting of: hydrogen, C₁ - C₆ alkyl, C₁ - C₆ alkyl substituted with at least one amino group, C₁ - C₆ alkenyl, C₁ - C₆ alkenyl substituted with at least one amino group, arylene, and alkylarylene.

21. The solution of claim 20, wherein each R¹ is individually chosen from the group consisting of: hydrogen, ethyl, methyl, propyl, iso-propyl, butyl, iso-butyl, sec-butyl, ter-butyl and acetyl.

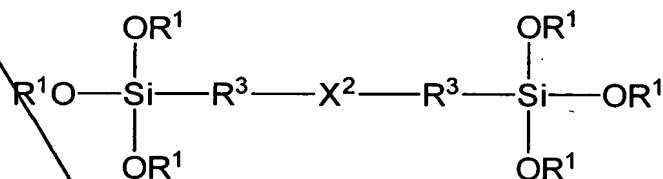
22. The solution of claim 20, wherein X¹ is chosen from the group consisting of: a C-Si bond, C₁ - C₆ alkylene, C₁ - C₆ alkenylene, C₁ - C₆ alkylene substituted with at least one amino group, C₁ - C₆ alkenylene substituted with at least one amino group, arylene, and alkylarylene.

23. The solution of claim 20, wherein each R² is individually chosen from the group consisting of: hydrogen, ethyl, methyl, propyl, iso-propyl, butyl, iso-butyl, sec-butyl, ter-butyl and acetyl.

24. The solution of claim 18, wherein said bis-silyl aminosilane comprises an aminosilane having two trisubstituted silyl groups, wherein the substituents are

individually chosen from the group consisting of hydroxy, alkoxy, aryloxy and acyloxy.

25. The solution of claim 24, wherein said bis-silyl aminosilane comprises:

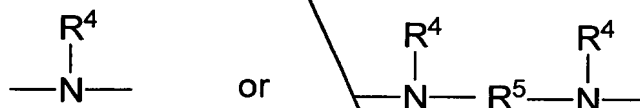


wherein:

-each R¹ is individually chosen from the group consisting of: hydrogen, C₁ - C₂₄ alkyl and C₂ - C₂₄ acyl;

-each R³ is individually chosen from the group consisting of: substituted aliphatic groups, unsubstituted aliphatic groups, substituted aromatic groups, and unsubstituted aromatic groups; and

-X² is either:



-wherein each R⁴ is individually chosen from the group consisting of: hydrogen, substituted and unsubstituted aliphatic groups, and substituted and unsubstituted aromatic groups; and

-R⁵ is chosen from the group consisting of: substituted and unsubstituted aliphatic groups, and substituted and unsubstituted aromatic groups.

26. The solution of claim 25, wherein each R¹ is individually chosen from the group consisting of: hydrogen, ethyl, methyl, propyl, iso-propyl, butyl, iso-butyl, sec-butyl, ter-butyl and acetyl.

27. The solution of claim 25, wherein each R^3 is individually chosen from the group consisting of: $C_1 - C_{10}$ alkylene, $C_1 - C_{10}$ alkenylene, arylene, and alkylarylene.

28. The solution of claim 25, wherein each R^4 is individually chosen from the group consisting of: hydrogen, $C_1 - C_6$ alkyl and $C_1 - C_6$ alkenyl.

29. The solution of claim 25, wherein R^5 is chosen from the group consisting of: $C_1 - C_{10}$ alkylene, $C_1 - C_{10}$ alkenylene, arylene, and alkylarylene.

30. The solution of claim 18, wherein said bis-silyl aminosilane is chosen from the group consisting of: *bis*-(trimethoxysilylpropyl)amine, *bis*-(triethoxysilylpropyl)amine, and *bis*-(triethoxysilylpropyl)ethylene diamine.

31. The solution of claim 18, wherein said vinyl silane is chosen from the group consisting of: vinyltrimethoxysilane, vinyltriethoxysilane, vinyltripropoxysilane, vinyltriisopropoxysilane, vinyltributoxysilane, vinyltriisobutoxysilane, vinylacetoxysilane, vinyltriisobutoxysilane, vinylbutyltrimethoxysilane, vinylmethyltrimethoxysilane, vinyllethyltrimethoxysilane, vinylpropyltrimethoxysilane, vinylbutyltriethoxysilane, and vinylpropyltriethoxysilane.

32. The solution of claim 18, wherein the ratio (by volume) of the total concentration of vinyl silanes to the total concentration of bis-silyl aminosilanes in said silane solution is at least about 1.

33. The solution of claim 32, wherein said ratio is at least about 4.

34. The solution of claim 18, wherein the total concentration of bis-silyl aminosilanes in said solution is between about 0.1% and about 5%, and wherein the total concentration of vinyl silanes in said solution is at least about 1%.

